Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

PUBLIC HEALTH REPORTS

VOL. XXVI JANUARY 27, 1911 No. 4

# REPORT ON AN OUTBREAK OF TYPHOID FEVER AT DES MOINES, IOWA, IN 1910

By L. L. LUMSDEN, Passed Assistant Surgeon, United States Public Health and Marine-Hospital Service

The investigation of the recent typhoid fever outbreak at Des Moines, Iowa, was made in compliance with a request to the Surgeon General of the Public Health and Marine-Hospital Service from the secretary of the Iowa State Board of Health.

The investigation was begun on December 22, 1910, and completed on January 7, 1911. It comprised a sanitary survey of the Raccoon River from Valley Junction to the filter galleries from which the water supply of Des Moines is obtained, bacteriological examinations of the water supply, an epidemiological study of about 50 individual cases of the disease, a review of the epidemiological data previously collected by the city health office, a study of the death records at the State health office, an inspection of a number of places such as dairies, grocery stores, and ice-cream manufactories, where foods are sold or prepared for sale, a careful inquiry into the origin and distribution of fruits, vegetables, and shellfish sold in the city during the period in which the outbreak was caused, a clinical study of a number of cases of the disease, a survey of the general sanitary conditions of the city, and a consideration of all other conditions which appeared to be likely to throw any light on the situation.

## TIME OF OCCURRENCE AND EXTENT OF OUTBREAK

As there is no law requiring a report of cases of typhoid fever in Des Moines, the records of deaths (supposed to be complete since 1905) give the only figures available from which the prevalence of the disease in recent years can be estimated. The following table and chart (No. 1), based on compilations from the records at the office of the State Board of Health, show the number of deaths reported from typhoid fever in Des Moines by months since January, 1905.

| Months | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | Total |
|---|---|---|---|---|---|---|---|
| January | 1 | 2 |  |  | 2 | 1 | 6 |
| February | 1 | 2 |  | 1 | 2 |  | 6 |
| March | 1 | 2 | 1 | 1 |  |  | 5 |
| April |  |  | 1 |  |  | 1 | 2 |
| May |  |  | 2 | 2 | 2 |  | 6 |
| June | 1 |  | 3 | 1 |  |  | 5 |
| July | 2 | 2 | 4 | 1 |  | 1 | 10 |
| August | 2 | 1 | 3 | 4 | 2 | 2 | 14 |
| September | 2 | 1 | 3 | 1 | 2 | 4 | 13 |
| October | 2 | 2 | 3 | 2 | 1 | 1 | 11 |
| November | 2 |  | 2 | 2 | 2 | 2 | 10 |
| December |  | 1 | 3 | 1 | 2 | 16 | 23 |
| Total | 14 | 13 | 25 | 16 | 15 | 28 | 111 |

It is evident that the number of deaths in December, 1910, was unusually high. Most of the deaths occurring in December were of persons who were taken sick in the latter part of November and in the early part of December.

Between November 25 and December 31, 1910, 209 cases were reported to the city health office. So far as can be ascertained the vast majority of these cases developed definite symptoms (took to bed) between November 15 and December 10. That this period of 25 days represents the time of occurrence of the outbreak proper is indicated by the results of (1) an investigation conducted by the city health officer, in which the dates of onset of 106 cases were carefully collected, and (2) an investigation conducted by the writer, in which the dates of onset of 50 cases reported during the outbreak were determined. The rate of admission of cases to the two largest hospitals of the city also points to this period as the time of occurrence of the outbreak. The time of admission of cases to hospital probably averaged about 5 days subsequent to dates of definite onset of illness. The rates of admission of cases to the Methodist and Mercy hospitals were as follows:

| Date of admission | Number of cases |  |  |
|---|---|---|---|
|  | Methodist Hospital | Mercy Hospital | Total |
| Oct. 1 to 14 |  |  |  |
| Oct. 14 | 1 |  | 1 |
| Oct. 15 to 28 |  |  |  |
| Oct. 28 |  | 1 | 1 |
| Oct. 29 to Nov. 15 |  |  |  |
| Nov. 15 | 1 |  | 1 |
| Nov. 16 to 22 |  |  |  |
| Nov. 22 | 1 | 1 | 2 |
| Nov. 23 | 1 | 2 | 3 |
| Nov. 24 |  | 2 | 2 |
| Nov. 25 | 6 | 4 | 10 |
| Nov. 26 | 1 | 2 | 3 |
| Nov. 27 | 3 | 5 | 8 |
| Nov. 28 | 3 | 1 | 4 |
| Nov. 29 | 3 | 3 | 6 |
| Nov. 30 | 4 |  | 4 |
| Dec. 1 | 3 |  | 3 |
| Dec. 2 | 2 | 1 | 3 |
| Dec. 3 | 3 |  | 3 |
| Dec. 4 | 3 |  | 3 |
| Dec. 5 | 1 |  | 1 |
| Dec. 6 | 2 |  | 2 |
| Dec. 7 |  |  |  |
| Dec. 8 |  | 1 | 1 |
| Dec. 9 | 1 |  | 1 |
| Dec. 10 |  |  |  |

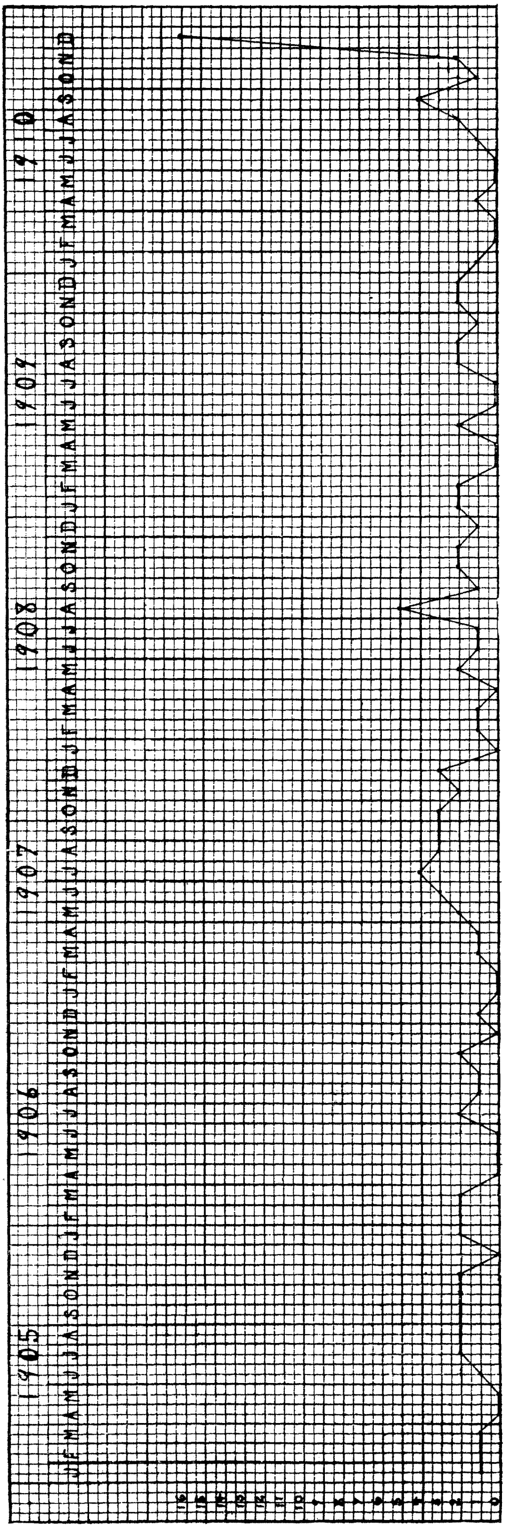


CHART No. 1.—Deaths from Typhoid Fever, by Months, from 1905 to 1911.

| Date of admission. | Number of cases. | | |
|---|---|---|---|
| | Methodist Hospital. | Mercy Hospital. | Total. |
| Dec. 11 | 1 | | 1 |
| Dec. 12 | 1 | 1 | 2 |
| Dec. 13 | | | |
| Dec. 14 | 1 | 1 | 2 |
| Dec. 15 | 1 | 1 | 2 |
| Dec. 16 | 2 | | 2 |
| Dec. 17 | | 1 | 1 |
| Dec. 18 | | 1 | 1 |
| Dec. 19 | | | |
| Dec. 20 | 1 | | 1 |
| Dec. 21 | | | |
| Dec. 22 | | | |
| Dec. 23 | | | |
| Dec. 24 | | | |
| Dec. 25 | | | |
| Total | 46 | 28 | 74 |

The time of high admission rate was from November 22 to December 7. The number of cases admitted to the two hospitals in this period was 57, while from October 1 to November 22 only 3 cases were admitted, and from December 7 to December 25 only 14 cases. The dates of onset of illness in the 50 cases which the writer investigated personally are shown in chart No. 2. The dates of onset, as given in this chart, were determined certainly with reasonably sufficient exactness and probably represent fairly accurately the rate of occurrence of all the cases developing during the outbreak.

From all the facts ascertained it seems certain that the outbreak began sharply about November 17, reached its maximum about November 24, and continued high, but at a gradually declining rate, until about December 7. Therefore, accepting 12 days as the usual incubation period of the disease in instances of sudden and extensive outbreaks, it appears that the chief cause of the outbreak became operative about November 5, reached its maximum about November 12, and continued until about November 25, when it either ceased entirely to operate or continued to operate, but at a markedly diminished rate.

The exact number of cases which occurred in the outbreak is not known. Inability to secure a report of cases which could be regarded as reasonably complete was a great handicap in the investigation. The lack of law requiring the reporting of cases of typhoid fever in Iowa and the existence of statutes which prohibit municipalities in the State from enacting ordinances requiring the reporting of local cases constitute a condition urgently needing immediate correction

Without legal enactment a prompt report of cases can not be reasonably expected and outbreaks may occur without the health authorities learning of them in time to have even a possible chance to apply preventive measures. The recent outbreak in Des Moines, it seems, was first brought to the attention of the authorities by publications in the local newspapers 10 or 15 days after the outbreak had begun. It is fortunate that the outbreak was learned of even at that early period, and the local press is to be congratulated for its vigilance.

Other communities in Iowa are liable at any time to be visited by outbreaks, and in some of these communities there may be no local press or one not so vigilant as that of the capital city.

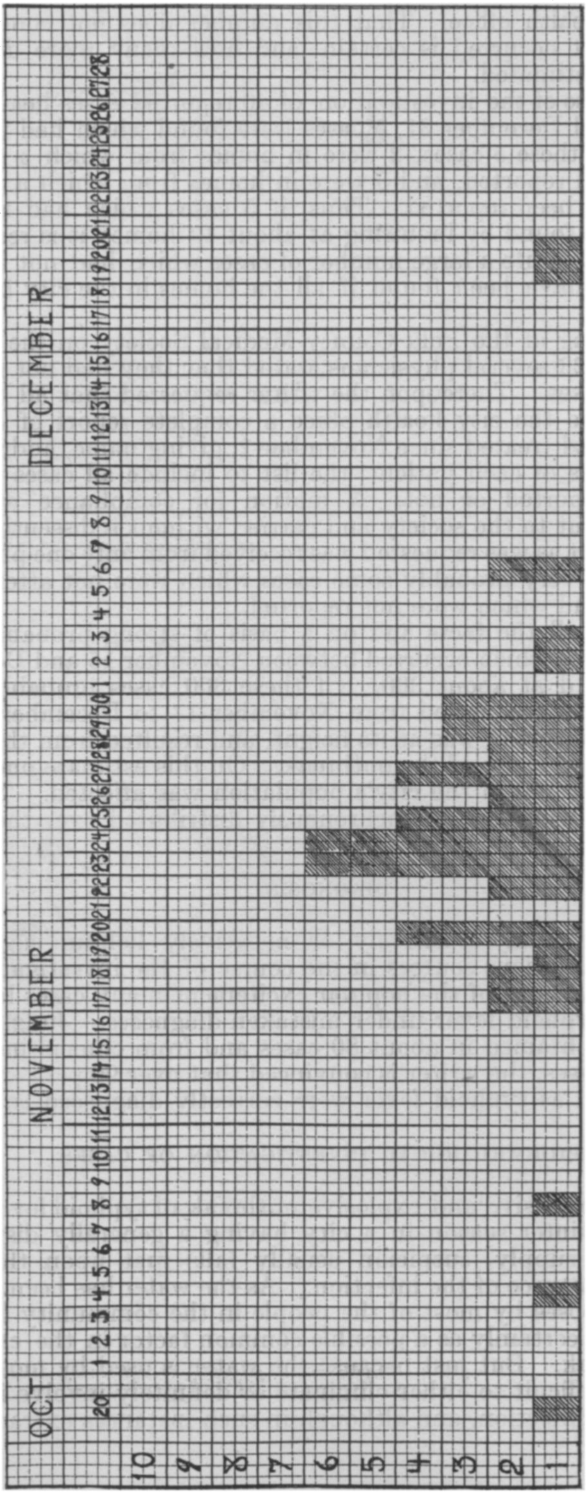


CHART No. 2.—Dates of Onset of 50 Cases Specially Investigated.

Between November 29 and December 31, 209 cases were reported to the city health office. That this number does not comprise all the cases that occurred is certain, and how many more did occur can only be estimated.

In the course of the investigation of 40 reported cases between December 27 and December 31, 5 cases were found which had not been reported. Of these 5 cases, 2 were in homes from which a previous case had been reported, and 3 were in homes from which a previous case had not been reported. Thus, if 5 cases which had not been reported were found by inquiring at about 40 homes it is reasonable to believe that quite a large number of cases which had not been reported could have been found if all the homes in the city had been canvassed.

At a meeting of the Polk County Medical Society on the evening of December 23 several physicians stated that they had not reported all of their cases. Thereupon the writer requested that all the physicians send to the city health office a complete report of all cases which they had treated since November 1, giving name, address, and onset of illness of each patient, the list to include all cases whether previously reported or not. A motion for compliance with this request was put to the society and carried without a dissenting vote, but such report as was requested was received from only one physician.

There were very probably some cases which were not attended by a physician and which were not reported.

In view of all the facts and on a basis of strong probability the number of cases which occurred between November 15 and December 31 is estimated at about 300. Of these 300 cases probably about 250 occurred in the period from November 17 to December 7, that is, when the outbreak was at its height, and resulted from the operation of the chief cause of the outbreak. On this estimate one person in about every 290 in the city's population was affected. That the infection was widely and synchronously distributed over the city is beyond question.

## DIAGNOSIS

Among the many positively or negatively helpful suggestions received from various sources in the course of the investigation one was that on account of the popular excitement many cases had been reported as typhoid fever under mistaken diagnoses. Judging from the histories obtained in about 80 cases and from clinical inspection of about 30 cases, the writer is convinced that over 90 per cent of the cases reported as typhoid fever were correctly diagnosed as such.

## EPIDEMIOLOGICAL INVESTIGATION OF CASES

When an extensive and explosive outbreak of typhoid fever occurs in the cold winter season in a city having a generally distributed public water supply, suspicion usually falls first upon the water supply as the source of the infection. As the water has been used for drinking purposes by most of the people in the community it has to be considered certainly as a possible common factor in the causation of the outbreak. But just because the water is used by most of the people it is difficult to either eliminate or definitely involve it as the source of the infection, and although in such instances extraordinary precautions should be taken at once to safeguard against the possible spread of infection by the water supply, final decision should not be rendered until after a thorough investigation has been made of the water supply and of the other possible sources of infection. To determine the possible sources of infection a careful epidemiological study of cases is necessary in order to ascertain to what conditions the persons affected were exposed prior to illness. As the facts are collected and studied one suspected source after another may be eliminated until the true principal source or sources of the infection can be determined, as a rule, with reasonable certainty.

Before the beginning of this investigation of the situation in Des Moines epidemiological data in regard to 106 cases reported after the beginning of the outbreak had been collected under the direction of the city physician, Dr. H. L. Sayler. From certain quarters some doubt as to the accuracy of these data was expressed on the ground that the canvass had been made hastily and by college students inexperienced in epidemiological work. For this reason, and also in order to collect data regarding certain conditions not covered by the canvass of the 106 cases, the writer personally investigated 51 cases. In the investigation of these 51 cases the homes of the patients were visited and a careful inquiry was made to ascertain all the facts called for by the following blank form:

### TYPHOID FEVER CASE CARD

Case No. —.
Name ———. Age ———. Sex ———. Nationality ———.
Date of first symptoms ———. Date took to bed ———.
Date of death ———. Date of recovery ———.’
Widal reaction positive or negative ———.
Rose spots ———. Intestinal hemorrhages ———.
Previous attack of typhoid ———. When ———.
Residence when taken sick ———, from ——— to ———.
Previous residence ———, from ——— to ———.
Subsequent residence ———, from ——— to ———.
Character of residence ———. Sewage disposal ———.
Water-closet in house ———. Water-closet in yard ———. Privy vault ———.
Conditions of sanitary devices ———. Relation of privy to well ———.
General sanitary conditions of residence:
Good ———. Fairly good ———. Rather bad ———. Bad ———.
Previous cases of typhoid in house ———.
Previous cases of typhoid in neighborhood ———.
Occupation ———. Where ———, from ——— to ———.
Water used at place of employment:
Solely ———. Principally ———. Occasionally ———.
Was patient away from Des Moines within 30 days prior to illness ———.
Where ———, from ——— to ———.
Exposed to known infection while away ———.
Water for drinking 30 days prior to illness:
Solely ———. Principally ———. Occasionally ———.
Soda water ———. Where ———.
Source of ice ———. How used ———.
Meals, where taken ———. Milk, how used ———.
Beverage ———. In cereals ———. In coffee or tea only ———.
Source of milk ———. Usually ———. Occasionally ———.
Milk used, boiled or pasteurized ———. Ice cream ———. Source ———.
Celery ———, lettuce ———, radishes ———, raw shell fish ———, apples ———.
Contact:
Association with patients in febrile stage.
Association with suspected cases.
Association with convalescents.
Association with persons who were in contact with patients.

Prophylaxis:
  Are stools disinfected ———. How ———.
  How disposed of ———. Is urine disinfected ———. How ———.
  How disposed of ———.
Other precautions:
  Efficient ———. Fairly efficient ———. Inefficient ———.
Name and address of attending physician ———.
Summary ———.
 Date of investigation.

——— ———,
*Investigator.*

Of the 51 cases investigated by Dr. Sayler and the writer, 43 had been covered in the previous canvass conducted under Dr. Sayler's direction, and the findings in the two separate investigations of these 43 cases were found to be in substantial agreement. That the findings of one investigation checked in salient features with the findings of the other is, of course, an indication of the accuracy of the findings in both investigations.

The 51 cases investigated were reported after the beginning of the outbreak. They were from among persons living in widely separated parts of the city and in all ways were selected so that they could be considered fairly representative of all the cases which occurred during the outbreak. The data collected in the investigation of these 51 cases, therefore, may be considered to indicate sufficiently accurately what would have been found generally true for all the cases occurring during the outbreak.

The findings and interpretations of the findings in these 51 cases were as follows:

### IMPORTED CASES

One of the cases was in a person who came to the city after onset of illness and who undoubtedly contracted the infection elsewhere. Another was in a person who had been away from the city about half of the time during the 30 days prior to illness and whose chances of contracting the infection in or away from the city were about equal. Three others were in persons who had been away from the city for a day or two or less during the 30 days prior to illness and whose chances of contracting the infection while away were estimated at about 10 per cent. All of the remaining cases (46) were in persons who had not been away from the city within the 30 days prior to onset of illness. From these findings it appears that in less than 2 per cent of the cases occurring during the outbreak was the infection contracted away from Des Moines.

## AGE AND SEX

For the 50 cases investigated and considered of local origin, the age and sex of the persons affected were as follows:

| Age, in years | Number of cases | | |
|---|---|---|---|
| | Male | Female | Total |
| 0 to 4 | ........ | 4 | 4 |
| 5 to 9 | 1 | 5 | 6 |
| 10 to 14 | 3 | 9 | 12 |
| 15 to 19 | 5 | 5 | 10 |
| 20 to 24 | 1 | 9 | 10 |
| 25 to 29 | 2 | 2 | 4 |
| 30 to 34 | ........ | ........ | ........ |
| 35 to 39 | 1 | 1 | 2 |
| 40 to 44 | ........ | 1 | 1 |
| 45 to 49 | ........ | 1 | 1 |
| Total | 13 | 37 | 50 |

In extensive outbreaks caused by milk-borne infection the proportion of cases in children under 10 usually is considerably larger than was that found among the cases in the Des Moines outbreak, as shown by the following table:

| Age, in years | Percentage of typhoid cases at specified age | | | |
|---|---|---|---|---|
| | Waterville, Me., 1903, caused by water | Stamford, Conn., 1895, caused by milk | Des Moines, 1910 | |
| | | | Sayler's 98 cases | Lumsden's 50 cases |
| 0 to 10 | 17 | 35 | 14 | 20 |
| 10 to 20 | 38 | 24 | 45 | 44 |
| 20 to 30 | 26 | 23 | 24 | 28 |
| 30 to 40 | 10 | 12 | 11 | 4 |
| 40 to 50 | 4 | 5 | 5 | 4 |
| 50 to 70 | 5 | 1 | 1 | 0 |
| Total | 100 | 100 | 100 | 100 |

It appears that in the Des Moines outbreak the age distribution of cases more nearly approached that usual in outbreaks due to water than that in outbreaks due to milk-borne infection.

### OCCUPATION

The following table gives the occupations of the persons affected:

| Occupations | Male | Female | Total |
|---|---|---|---|
| School children | 8 | 18 | 26 |
| Watchmakers | 1 | .......... | 1 |
| Housewives | .......... | 3 | 3 |
| Telegraph-instrument fixers | 1 | .......... | 1 |
| Telephone-office clerks | .......... | 2 | 2 |
| Students (university) | .......... | 2 | 2 |
| Bookkeepers | .......... | 1 | 1 |
| Ice-wagon drivers | 1 | .......... | 1 |
| Salesmen and saleswomen | .......... | 1 | 1 |
| Seamstresses | .......... | 1 | 1 |
| Cashiers (store) | 1 | .......... | 1 |
| Waiters and waitresses (restaurant) | .......... | 1 | 1 |
| Firemen (city) | 1 | .......... | 1 |
| Newspaper-advertising solicitors | .......... | 1 | 1 |
| Laundresses | .......... | 1 | 1 |
| Milliners | .......... | 1 | 1 |
| No occupation | .......... | 5 | 5 |
| Total | 13 | 37 | 50 |

It is evident that the disease was distributed through the population regardless of occupations in which persons were engaged.

### CHARACTER AND GENERAL SANITARY CONDITION OF RESIDENCES

Four of the cases were in persons living in rooming houses, 3 among persons in apartment houses, 4 among persons in public institutions (boarding schools), and the remaining 39 were among persons who lived at private residences. The disease certainly did not appear to prevail at a disproportionately high rate among persons who would be most closely associated with transient visitors to the city.

Twenty-three of the cases occurred at residences where the general sanitary conditions were good, 20 at residences where the general sanitary conditions were fairly good, and 7 at residences where the general sanitary conditions were rather bad. From these findings it appears that the disease did not prevail disproportionately among persons living in insanitary neighborhoods and, therefore, that in the causation of the outbreak faulty sanitary conditions at place of residence of persons affected did not constitute an important factor.

### SEWAGE DISPOSAL

Thirty-three of the cases occurred at residences connected with the city sewerage system and at which water-closets were used, and 17 at residences not connected with the city sewerage system and at which privy vaults or surface privies were used. No instance was met with in which it appeared likely that faulty plumbing or seepage from privy to well could have been responsible for the infection.

### FOODS AND BEVERAGES

The season of occurrence, the geographical distribution, and the general features of the outbreak taken together definitely eliminated flies and other insects and contact infection as major factors in the causation of the outbreak, and from the outset it seemed on general principles, drawn from present knowledge of the modes of spread of typhoid fever, that the outbreak had been caused by infection in some beverage or foods which had been widely distributed over the city. Therefore, in the epidemiological investigation of cases it was endeavored to ascertain as nearly exactly as possible just what foods and beverages, liable to convey infection, had been used by the persons affected, in order to determine which foods and beverages could be eliminated and which involved as the principal source of infection.

### MEALS—WHERE TAKEN

Of the 50 cases, 45 were in persons who had taken meals within the 30 days prior to illness at their places of residence only, 3 in persons who had taken meals at their places of residence usually, but at restaurants occasionally, and 2 in persons who had taken meals usually at restaurants and boarding houses.

From these data it is certain that the outbreak was not caused by infection introduced into foods and beverages at public eating places.

### MILK

In cities where large milk dealers distribute their supplies over large territories extensive and widespread outbreaks of typhoid fever may be caused by milk-borne infection. Outbreaks caused by milk occur most frequently in the summer and early fall, but as milk is a favorable culture medium for the typhoid germs such outbreaks may occur at any season of the year. The likelihood of milk being the source of the infection causing the Des Moines outbreak, therefore was given particular consideration.

The 50 cases investigated gave the following history as to the way in which milk was used during the 30 days prior to illness:

| | |
|---|---|
| As a beverage | 16 |
| In fruits or cereals, but not as a beverage | 15 |
| In hot tea or coffee only | 14 |
| As ice cream only | 2 |
| Not in any way | 3 |

The proportion of cases giving a history of having used milk as a beverage is one point in the evidence that the outbreak was not due to milk, as in outbreaks due to milk the proportion of cases among milk drinkers is usually considerably larger.

There was no disproportionately large number of cases among the customers of any dairyman. Of the 50 cases specially investigated 2 used milk from their own cows only, 3 used no milk in any way, and the remaining 45 cases were distributed among the customers of 25 different dairymen. The source not only of the milk used habitually, but also of that used occasionally (as from grocery stores, for instance), was ascertained as completely as possible for each case. Sixteen of the cases gave a history of having used habitually or occasionally milk sold by the largest dealer in the city and 8 of having used milk sold by the second largest dealer in the city. These two dealers sell about 50 per cent of the milk distributed in Des Moines, so that the number of cases among their customers was entirely proportionate to their business. Groups of cases in widely separated parts of the city occurred synchronously and absolutely disconnected in respect to the source of milk used prior to illness.

Two or more cases developing at about the same time in the same household is of frequent occurrence in milk outbreaks, but this was of very infrequent occurrence in the Des Moines outbreak. In outbreaks due to milk a considerable proportion of cases, particularly in children, will have a sudden onset of illlness without prodromal symptoms, while over 90 per cent of the cases in the Des Moines outbreak gave a history of prodromes.

In view of all these facts the milk supply can be eliminated, beyond reasonable doubt, as the chief and primary source of the infection which caused the recent outbreak in Des Moines. If milk operated as a factor it must have done so in a secondary way, the bottles or cans becoming infected by being exposed in some way to germs which had already been distributed through some other medium.

### ICE CREAM

Fifteen of the cases were in persons who had eaten ice cream within the 30 days prior to illness, 30 cases gave a history of not having eaten ice cream, and for 5 accurate information regarding the eating of ice cream was not obtainable. The 15 cases giving a history of having eaten ice cream were among the customers of several different ice-cream makers. Evidently ice cream can be eliminated as a considerable factor in the production of the outbreak.

### RAW SHELLFISH

Only 1 case out of the 50 gave a history of having eaten raw oysters or clams within 30 days prior to illness, so that raw shellfish may be definitely eliminated.

### SODA WATER

The history of the 50 cases in regard to the drinking of soda water within the 30 days prior to illness was as follows: Yes, 2; no, 44; not determined, 4. Soda water could not have been a considerable factor.

### ICE

Two cases were in persons who had used ice in beverages, while 48 gave a definite history of not having done so. Ice can be eliminated as a considerable factor.

### RAW VEGETABLES AND FRUITS

Most persons will give a history of having eaten some kind of raw fruits or vegetables within any period of 30 days, so as a rule these products can not be definitely excluded on the history of the cases alone as possible sources of infection. Yet when the history of the cases in respect to the eating of the different fruits and vegetables is considered along with the general features of the outbreak and the likelihood of any particular supply of possibly infected fruits or vegetables having been distributed so as to have reached the persons affected, reasonably definite conclusions may be formed. The history of the cases in regard to the eating of vegetables and fruits within the 30 days prior to onset of illness was as follows:

| Fruit or vegetable | Yes | No | Not definitely determined | Total |
|---|---|---|---|---|
| Celery | 18 | 31 | 1 | 50 |
| Lettuce | 6 | 42 | 2 | 50 |
| Radishes | 1 | 48 | 1 | 50 |
| Apples | 29 | 5 | 16 | 50 |

Thus, the history of the cases alone is sufficient to exclude all of these except apples as having been a possibly major factor in the causation of the outbreak. From what is known about the viability of the typhoid bacillus and the way in which apples are gathered and subsequently handled it would certainly seem highly improbable that apples could have been responsible for such an outbreak as the recent one in Des Moines, even if every case had given a definite history of having eaten apples. Furthermore, it was found that the apples eaten by the persons affected had been distributed from the storehouses of at least three of the large wholesale dealers in the city, and it is contrary to the laws of probability that each of these dealers, obtaining his supply of apples from different sources, would have been selling highly infected apples in November, 1910. In view of all the evidence, fruits and vegetables may be eliminated, beyond reasonable doubt, as having played a very considerable part in the causation of the outbreak.

### CONTACT

Only two of the cases gave a history of free association with previous cases in the febrile stage of the disease and were attributable to infection by contact. These two cases had onsets of illness on December 19 and December 20, respectively, and had lived in the same house with and helped nurse a case whose onset of illness was November 22. A considerable proportion of the cases occurring since the 10th of December probably would be found to be attributable to contact infection; but all the evidence indicates that in the outbreak, contact operated only as a factor secondary to some other, which was chief and primary.

### WATER

Of the 50 cases, 49 gave a history of having used the city water unboiled as the sole or principal source of drinking water during the 30 days prior to illness. The one case giving a history of not having used any city water not previously boiled was one of the cases attributed to contact infection and referred to above.

Of the 49 cases, 41 had used the city water solely, while 8 had used the city water principally, but water from some other sources, such as wells, occasionally. Thus the city water presents itself as a common factor, and certainly as a possible chief source, of the infection which caused the outbreak. Along with this fact the season of occurrence, the extent and the explosive character of the outbreak, the distribution of the disease in relation to the distribution of the water supply, and the exposure of the water supply to dangerous pollution constitute a very strong chain of evidence that the city water was the source of the infection which caused the outbreak.

## POLLUTION OF THE WATER SUPPLY

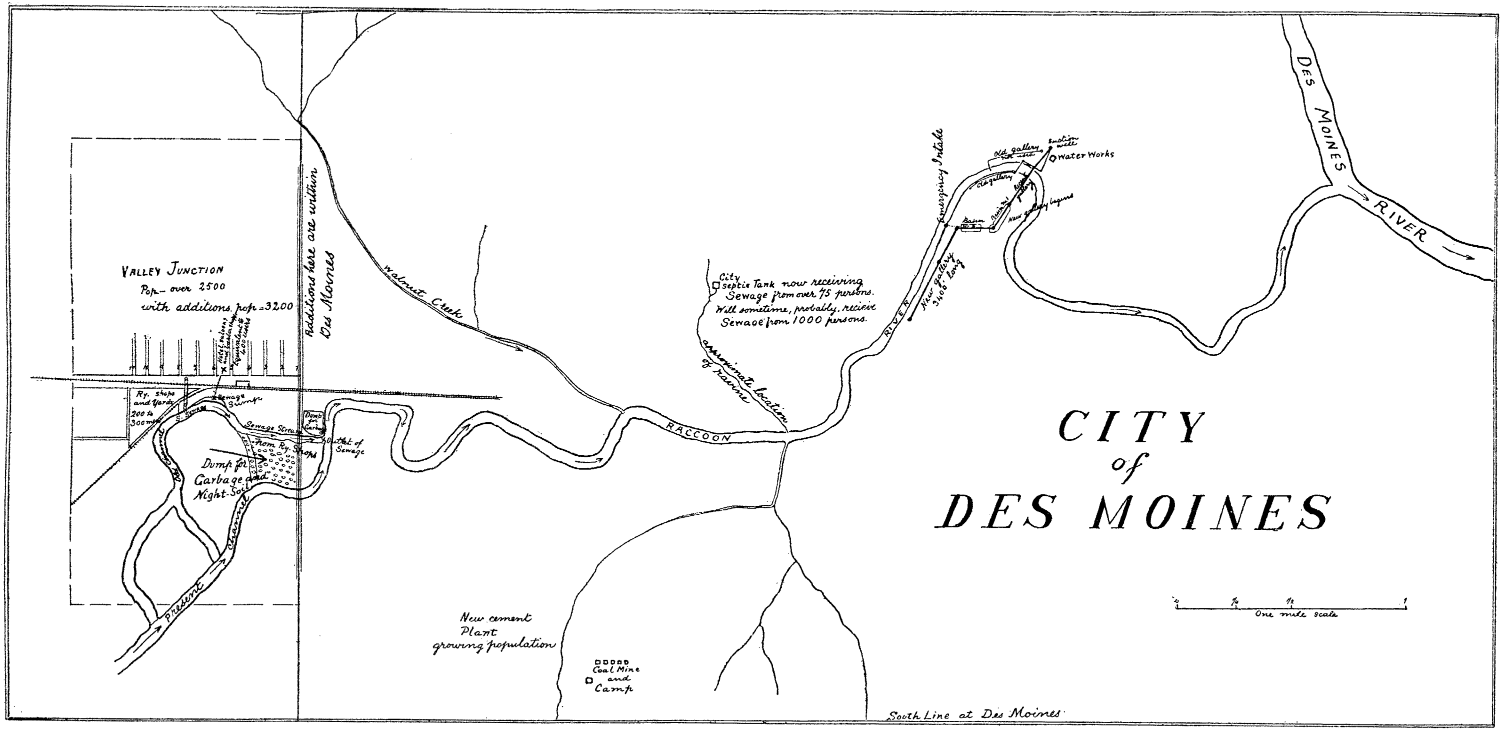
As the water from a new gallery was turned into the city supply at about the same time as the outbreak occurred, and as it had been observed that proper sanitary arrangements were not provided for the men engaged in the work while the construction of this gallery was going on, it was assumed by many people in the community that the outbreak had been caused by infection in the water from the new gallery.

The officials of the Des Moines Water Co. state that none of the water from the new gallery could have entered the city supply before November 15, and that little if any water from the new basins could have entered the city supply before November 30, when the gate of the new gallery was opened and the water taken from the river and filtered through the new sand basins first entered the city supply. According to this information the water from the new gallery, although possibly contributing somewhat, could not have been the sole source of the infection which caused the outbreak, since the period of causation of the main outbreak, as determined by onset of cases, was from about November 5 or 10 to about November 25 or 30.

According to further information received from the water company the scraping away of the surface sand over the two filtration galleries crossing the river, which had been done from time to time throughout the summer and fall in order to secure more rapid filtration of the water from the river into these galleries, was done to a greater extent in the week ended November 5 than in any other week of the year. The next largest amount of scraping for any one week was in the week ended November 12, and the last scraping of the sand over the river galleries was done on November 26. Beginning on November 10 and continuing for some time thereafter a centrifugal pump was operated on the water in the river galleries. This pumping was for the purpose of producing a negative pressure in the galleries, so that the filtration of the river water through the sand over the galleries crossing the river would be more rapid. The time of the unusual amount of scraping of the sand over the river galleries, and the work of the centrifugal pump on these galleries in relation to the period of causation of the outbreak is very suggestive of cause and effect.

According to the description of the work as given by the water company it would seem that there was ample opportunity for dangerous pollution to enter the city water supply during the period extending from November 5 to November 26, provided there was dangerous pollution in the water of Raccoon River as it flowed over the galleries at that time.

As to the dangerous pollution of the Raccoon River at points within a few miles above the location of the galleries there is no question whatever. The attached map, prepared by Prof. Lafayette Higgins, engineer of the Iowa State Board of Health, and based on observa-



Map of Raccoon River showing pollution of river between Valley Junction and location of filtration galleries from which water supply of Des Moines is obtained.

tions made conjointly by Prof. Higgins and the writer, will give some idea of the pollution of the Raccoon River with human excrement at Valley Junction and at points between Valley Junction and the location of the galleries from which the water supply of Des Moines is obtained. Considering the amount of pollution which enters the river, there is no room for doubt that typhoid infection may more or less continuously reach the water of the river below Valley Junction and above (upstream from) the Des Moines filter galleries.

According to information received from the physicians of Valley Junction there were cases of typhoid fever under treatment in Valley Junction in October and November, 1910. The occurrence of cases as given was as follows: In September, 3; October, 4; November, 5; and in December, 1.

## BACTERIOLOGICAL EXAMINATIONS OF THE DES MOINES CITY WATER SUPPLY

Since this investigation was not begun until December 22, the bacteriological study of the water could not be expected to throw any very definite light on what was the condition of the water when the outbreak was caused. Therefore the bacteriological examinations were made with a view principally to determining if the filtration of the water under what may be called ''normal'' conditions of filtration could be relied upon entirely to remove from the river water and from the ''ground'' water obtained from the river basin such disease-producing microorganisms as might be present in the water. Bacteriological examinations were not made of the river water above the filter galleries because they were not considered necessary, the sanitary survey of the river from Valley Junction down showing more unmistakably than bacteriological examinations could that the river is dangerously polluted with human excrement.

Efforts were not made to recover typhoid bacilli from the water for the following reasons:

1. Negative findings at this time would have been no indication of conditions at the time the outbreak was caused.

2. From waters containing typhoid bacilli in sufficient numbers to cause a very high rate of prevalence of typhoid fever among persons using such waters the isolation of the organisms is, by present bacteriological technique, very diffcult and largely a matter of chance. Only a few ounces of water a day can be properly examined for the presence of the typhoid bacillus and though none of the organisms might be found in the few ounces examined, quite a number might be at the same time present in the hundreds of gallons of water drunk by the people in the community supplied; therefore, in a search for typhoid bacilli under such circumstances negative findings can be expected and such negative findings throw no light whatever on the situation.

Samples of water from the following sources were examined:

1. Siphon well, this sample representing the mixture of effluents from all the filtration galleries.
2. Pumping station, this sample representing the water just before it is pumped into the mains for distribution to the city.
3. Tap at the laboratory building, at Fourth and Center Streets; and
4. Tap at the city hall; the last two representing the water after it has traversed the city mains.

The dates and results of the examinations are presented in the following table:

| Source of sample | Date of examination (planting) | Number of bacteria on agar plates from 1 cc. after 48 hours incubation at 37° C | Number of red colonies on lactose litmus agar plates from 1 cc | Fermentation with gas production after 48 hours in lactose bouillon | | | | B. coli in— | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 cc | 5 cc | 10 cc | 20 cc | 1 cc | 5 cc | 10 cc | 20 cc |
| Laboratory tap | Dec. 25, 1910 | 16 | .......... | + | ..... | + | ...... | + | ..... | ...... | ...... |
| Siphon well | Dec. 26, 1910 | 16 | .......... | – | ..... | + | ...... | – | ..... | – | ...... |
| Pumping station | do | 14 | 1 | – | ..... | – | ...... | – | ..... | – | ...... |
| Laboratory tap | do | 12 | 1 | – | ..... | + | ...... | – | ..... | + | ...... |
| Do | Dec. 29, 1910 | 3 | .......... | – | ..... | – | ...... | – | ..... | – | ...... |
| City Hall tap | Dec. 31, 1910 | 2 | .......... | ..... | – | ...... | ...... | ..... | – | ...... | ...... |
| Laboratory tap | do | 1 | .......... | ..... | – | ...... | ...... | ..... | – | ...... | ...... |
| Do | Jan. 2, 1911 | .......... | .......... | ..... | ..... | ...... | – | ..... | ..... | ...... | – |

It should be noted that the bacterial counts were made from the number of colonies on agar plates incubated at 37° C, and not on gelatin plates incubated at 20° C, the medium and temperature usually employed in making bacterial counts of water. Gelatin plates will usually give somewhat higher counts than will agar plates. The laboratory was not equipped for the use of gelatin plates.

The proportion of samples of the city water taken prior to December 29 which gave fermentation in lactose-bouillon and which contained colon bacilli is significant. The presence of colon bacilli in the city water in such numbers indicates that even at that time the filtration of the water was not efficient to remove from the river water whatever dangerous pollution it might have contained. That the filtration was still less efficient in the early part of November, when the filtration was being forced, is certainly a reasonable deduction.

The improvement in the city water, as shown by the results of the examinations of samples taken on and after December 29 is striking. The three samples examined on and after that date gave average counts of two bacteria to the cubic centimeter, and none gave fermentation in lactose bouillon or other indication of the presence of the colon bacillus. The results of the examinations of these three samples compare favorably with those usually obtained from examinations of waters from deep wells of unquestionable safety. Should the water supply of the city of Des Moines be maintained constantly in the condition in which it was found to be at the time these last three samples were taken, it certainly would appear to be safe, so far as bacterial content is concerned, and to need no boiling previous to use.

## CHEMICAL TREATMENT OF THE WATER SUPPLY

According to information received from officials of the water supply, chemicals were applied to the whole or a part of the city water supply from July 1 to December 25, 1910, on the following dates:

July 7 and 8, December 5, 7, 8, 14, and 15, and after 4.45 p. m. of December 26 the whole city supply was treated with hypochlorite of lime. Therefore the improvement of the city water noted in the samples examined on and after December 29 may be attributed to the use of hypochlorite and not necessarily to any extent to more efficient filtration.

On the evening of December 26 the writer was apprised by a representative of the water company of the use of and the contemplated continued use of hypochlorite in the water, and therefore the difference in findings in the examinations of the water made subsequent to that date occasioned no surprise.

## GEOGRAPHIC DISTRIBUTION OF THE OUTBREAK IN RELATION TO THE DISTRIBUTION OF THE WATER SUPPLY

So far as could be ascertained, the occurrence of cases in the outbreak was largely confined to persons living in districts supplied by the city water. Districts of the city, containing altogether probably about 10,000 to 15,000 of the city's population, not supplied with city water, but with water from wells, remained singularly free from the disease. Most of the cases learned of in these districts were found on investigation to be in persons who had used the city water on frequent occasions while on visits of a business or social nature to other parts of the city. Fort Des Moines, located 5 miles from the city, but supplied with water from the Des Moines supply, had 3 cases. These 3 cases had their onsets of illness as follows: Two on December 2 and 1 on December 19. The first 2 cases gave a history of not having eaten when on visits to the city any foods such as are considered likely to serve as media of typhoid infection. The last case to develop at Fort Des Moines gave a history of having drunk milk at restaurants in the city on several occasions within the two or three weeks prior to illness. The population of the fort is about 900, so that the disease evidently prevailed there during the outbreak at about the same rate as it did in the city. The distribution of the disease in relation to the city water supply is very significant.

## CONCLUSIONS

1. The outbreak of typhoid fever in Des Moines in November and December, 1910, was caused, beyond reasonable doubt, by infection disseminated in the city water obtained from the Raccoon River and Raccoon River basin. A small proportion of the cases may have been caused by infection received immediately through personal contact, milk, vegetables, fruits, etc., but the vast majority of the cases resulted from infection distributed primarily and chiefly in the city water supply. This conclusion is based on the following points of evidence:

(*a*) The season of occurrence and the explosive character of the outbreak.

(*b*) The distribution of the disease in relation to the distribution of the city water.

(*c*) The pollution of the Raccoon River at points within a few miles upstream from the location of the filtration galleries.

(*d*) The results of the bacteriological examinations of the water, showing that even about a month after the scraping away of the upper layer of sand from over the filtration galleries crossing under the river and the working of a centrifugal pump on these galleries, in order to secure rapid or forced filtration, had been discontinued, the filtration was still inefficient to remove from the water, to a reasonably reliable extent, such disease-producing microorganisms as the water in the river and the river basin may have contained.

(*e*) The correspondence in time between the period of special forcing of the filtration galleries and the period of main causation of the outbreak.

(*f*) The decline in the outbreak in due time, according to what is known about the viability of the typhoid bacillus in water and sand, after the forcing of the filtration had been discontinued and after the time in which the bulk of whatever infection may have reached the sand of the new basins, as a result of the lack of proper sanitary precautions while the work on these new basins was going on, probably would have elapsed.

(*g*) The results of the epidemiological studies of the cases, which implicate the city water supply and which definitely eliminate, except perhaps as secondary and minor factors, all other media which according to the whole history of the epidemiology of typhoid fever, could be reasonably considered to have served to convey infection causing an outbreak of such character.

2. The water supply as obtained from the filtration galleries is thoroughly susceptible to purification from whatever bacterial disease-producing organisms it may contain by the proper use of hypochlorite of lime; and when it is assured that the whole supply is being properly treated at all times with hypochlorite the water may be used, certainly with reasonable safety, for drinking and other domestic purposes without boiling previous to such use.

3. The milk supply and the general food supply of the city can be definitely eliminated as the chief and primary source of the infection which caused the recent outbreak, but it is readily conceivable, in view of the way in which much of the milk in the city is handled, that cans and bottles and consequently the milk itself were exposed to whatever infection was in the water or upon the hands of persons working in public dairies; and, therefore, milk may have operated to some extent as a secondary factor. Milk and other food supplies of the city, as handled at present, are liable at any time in the future to be important sources of infection and therefore should be made subject to official inspection as soon as practicable.

4. Most of the privy vaults and privies in the city are of very faulty construction and constitute a menace to the health of the city in respect not only to typhoid fever but to all other diseases caused by organisms disseminated from faultily disposed of human excrement. The danger from these faulty privies will be greatest during the summer weather when flies and other insects are abundant.

## RECOMMENDATIONS

1. Safeguard the city's water supply.—To accomplish this the following measures are suggested:

(*a*) Protection of the Raccoon River on both sides from sewage pollution at points upstream from the location of the filtration galleries as far as Valley Junction certainly and as much farther upstream as practicable. The Des Moines sewers could be extended to receive the sewage from Valley Junction, or the sewage from Valley Junction could be subjected to purification before being discharged into the river. The dumping of night soil from the privies of Valley Junction at places where it will be liable to seep or be washed into the river should be prohibited. Special attention should be given to surface drainage toward the river from privies at settlements located to the south (the right bank) of the river and within 5 or 6 miles up country from the filtration galleries.

(*b*) The abandonment as soon as practicable of the filtration galleries which cross under the river and their replacement with closed conduits, so that the whole water supply will be received from the sand basin to the south side (right bank) of the river.

(*c*) Until the above changes, *a* and *b*, have been effected and until the safety of the water as then delivered has been determined by prolonged and careful bacteriological and chemical studies conducted by competent and officially appointed investigators, the whole water supply should be treated constantly and under official supervision with hypochlorite of lime applied in accordance with methods approved by unbiased expert opinion.

(*d*) Until definitely and officially assured that the water has been made safe by the use of hypochlorite of lime, the people should be advised to boil the city water before using it for drinking purposes.

The enactment of an ordinance requiring that all water sold in the city of Des Moines shall be within certain chemical and bacteriological standards of purity is suggested.

2. Use every effort to secure legislation which will require the prompt reporting of all cases of typhoid fever in the State of Iowa. This is urgently and immediately important. Without such law outbreaks due to readily removable causes may go on in different communities for some time before being discovered, and so cause much needless and preventable suffering and loss of life.

3. Secure official inspection of dairies and dairy farms and of other places where public food supplies are sold or prepared for sale. The enactment of an ordinance requiring the pasteurization of milk and sterilization of all milk cans and bottles, under official supervision, is suggested.

4. Abolish all faulty privy vaults and surface privies and replace them with privies provided with water-tight vessels for receiving the excrement, and constructed so that flies and other insects will not have access to the excrement.

5. Have all cases of typhoid fever investigated and the precautionary measures to prevent spread of infection from the bedsides of patients officially supervised by the local health officer.